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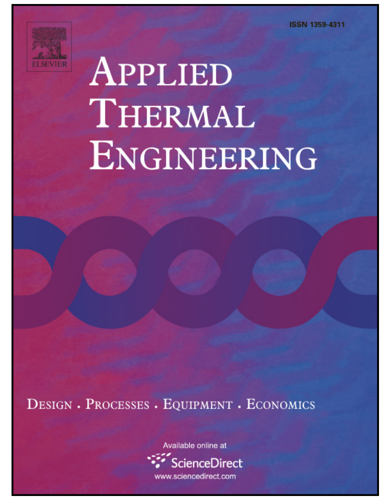

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Qi Chen, Xiaosong Zhang

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Modeling and Data Analysis of Multistory Flat Plate Quasi-Counter-Flow Membrane Dehumidifier

CHEN Qi, ZHANG Xiaosong*

(School of Energy and Environment, Southeast University, Nanjing 210096, Jiangsu, China)

Abstract

A two-dimensional steady-state heat and mass transfer mathematical model is established to study the performances of air-to-liquid dehumidifier with PVDF ultrafiltration membrane in liquid desiccant dehumidification in this paper. Terms in this mathematical model are amended with experimental data and improved with the method of calculating enthalpy of lithium chloride solution. The mean Nusselt number in air channel and mean Sherwood number are calculated and the correlations are fitted with the relevant quantities for predicting the heat and mass transfer coefficients. Furthermore, the corresponding heat and mass transfer coefficients are obtained and substituted as initial conditions into the mathematical model. Meanwhile, according to the relationship between the moisture content difference and water vapor partial pressure difference between inlet and outlet on air side, the diffusion coefficient is modified to meet the actual situation of the experiment. Joint surface renewal rate is proposed and regarded as a comprehensive index describing the relative motion of the fluids on both sides in the membrane dehumidification process. After analyzing the influences of controlled variables on mass transfer coefficient divided by density, the conclusion is obtained that the variable solution temperature group is inferior to the variable solution concentration group. The importance of maintaining low solution temperature during the dehumidification process is emphasized.

Keywords:

mathematical model, quasi-counter-flow, liquid desiccant dehumidification, joint surface renewal rate, correlations

1. Introduction

The application of membrane technology in air humidity control provides advantages over the conventional treatment methods such as condensation dehumidification with the disadvantage of high energy consumption and direct-contact absorption with the risk of air contamination by the absorbent. In membrane contactors the desiccant solution is separated from the humid air by a micro-porous semi-permeable membrane. Humid air and desiccant solution can be operated independently along each channel with sufficient membrane contact area provided. And new problems emerged at the same time that real contact area per unit flow are small, meanwhile, the contact efficiency is lower than the conventional air-liquid direct-contact type due to the presence of membrane, so measures need to be taken to improve the dehumidification efficiency. After employing the long and narrow channel structure, the dehumidification efficiency is greater than the cooling efficiency in quasi-counter-flow membrane dehumidifier [1]. Counter-flow channel arrangement is adopted and refrigeration tubes containing cold water are arranged inside the desiccant solution channels to enhance the cooling capacity and maintain low temperature of desiccant solution [2]. The experimental results verified the improvement in dehumidification efficiency. Zhang L Z.'s previous research result shows that the less the